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Sussman

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(54) **SENSOR FOR SIGHT IMPAIRED INDIVIDUALS**

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(52) **U.S. Cl.** .................... **340/573.1**; 340/407.1; 434/116; 342/24

(58) **Field of Search** .................... 340/573.1, 407.1; 348/62; 434/116; 342/24

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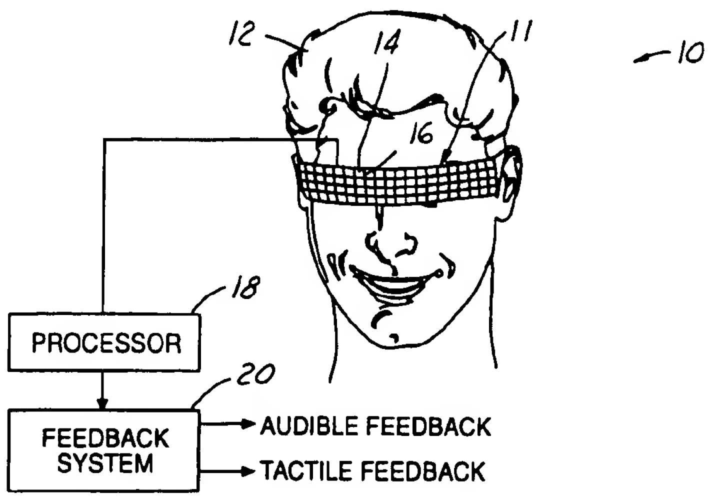
(57) **ABSTRACT**

A sensory system and method for a visually impaired user includes an array of laser transmitters for transmitting laser signals in given areas corresponding to each of the laser transmitters. An array of laser sensors are provided for receiving laser signals reflected from objects in the corresponding given areas with each laser sensor corresponding to a respective one of the array of laser transmitters. The time between transmitted and received laser signals of a laser transmitter and the respective laser sensor is indicative of the distance between the user and an object in the corresponding given area. A processor is operable with the laser transmitters and laser sensors to effect scanning of the given areas by the array and to process the transmitted and received signals to determine the distance between the user and an object in the given areas. A feedback system is operable with the processor for generating a feedback signal for each of the laser sensors as a function of the received laser signals. The sensing system and method may also include an array of ultrasonic transducers.

**20 Claims, 2 Drawing Sheets**



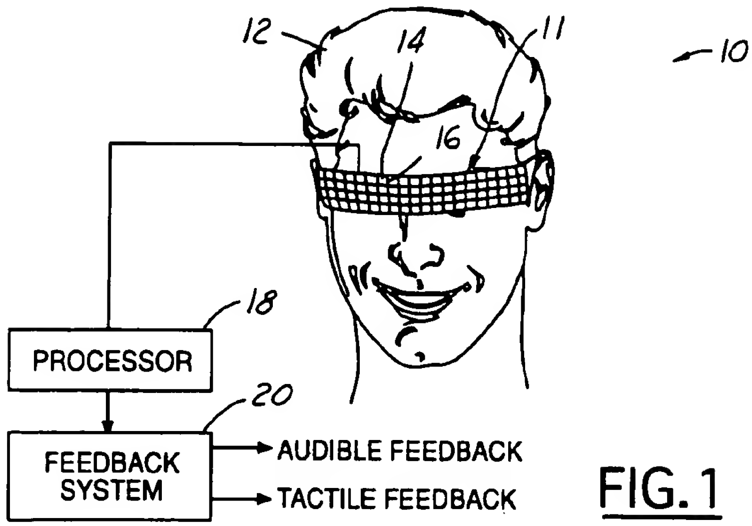



FIG. 1

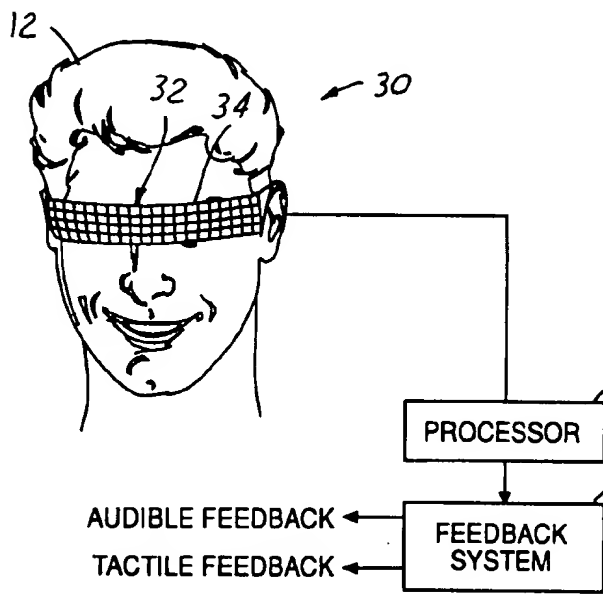



FIG. 2

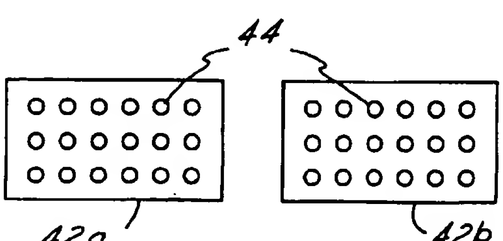



FIG. 3

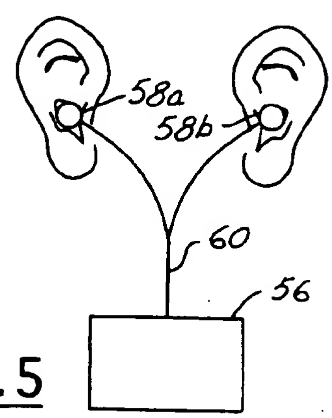



FIG. 5

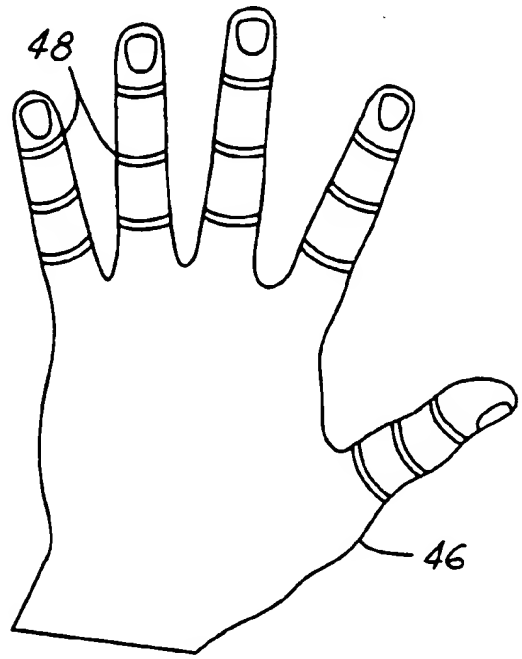

48
46

FIG.4

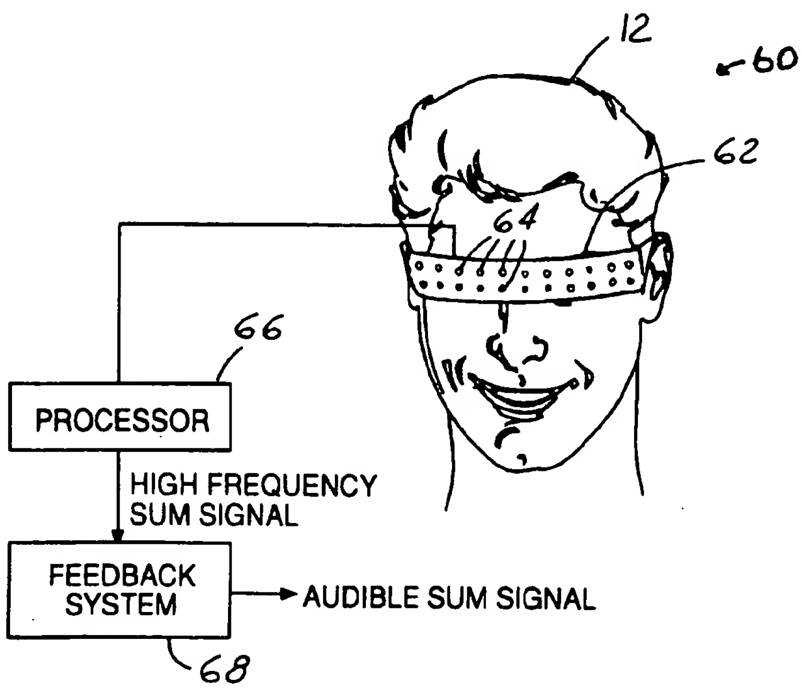

12
60
62
64
66
PROCESSOR
HIGH FREQUENCY
SUM SIGNAL
FEEDBACK
SYSTEM
AUDIBLE SUM SIGNAL
68

FIG.6

# SENSOR FOR SIGHT IMPAIRED INDIVIDUALS

## TECHNICAL FIELD

The present invention relates generally to obstacle detection devices for the blind and, more particularly, to a sensing array for the blind.

## BACKGROUND ART

A variety of mobility aids have been developed to provide the blind with a means of traveling independently, confidently, and quickly. These aids include sensory devices for sensing potential obstacles. The sensory devices typically transmit a signal in a beam towards an area and then listen to receive a signal reflected off of an object in the area. Because the propagation velocity of the signal is known, the time between the transmit and reflected signals is indicative of the distance of the object from the sensory device.

A primary disadvantage with the prior art is in "sensing" the space between objects, as well as sensing the general outline of the objects themselves. For example, a blind person walking down the street would like to distinguish between people, mail boxes, trees, etc., and of the gaps between them. In essence, the blind person would like to be able to form a mental picture or "footprint" of the surrounding environment. The blind person would also like to be able to form the mental picture from tactile stimulation and/or auditory signals as quickly and accurately as possible. The prior art is devoid of such a sensory device.

## SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a sensory system which enables a visually impaired user to obtain a mental picture of the surrounding environment.

It is another object of the present invention to provide a sensory system having an array of transmitters and sensors operable to enable the visually impaired user to obtain a mental picture of the surrounding environment.

It is a further object of the present invention to provide a sensory system having an array of ultrasonic transducers.

It is still another object of the present invention to provide a sensory system having an array of laser transmitters and laser sensors.

In carrying out the above objects and other objects, a sensory system for a visually impaired user is provided. The sensory system includes an array of laser transmitters for transmitting laser signals in given areas corresponding to each of the laser transmitters. The system further includes an array of laser sensors for receiving laser signals reflected from objects in the given areas with each laser sensor corresponding to a respective one of the laser transmitters. The time between transmitted and received laser signals is indicative of the distance between the user and an object in the corresponding given area.

A processor is operable with the laser transmitters and laser sensors to effect scanning of the given areas by the array. The processor also processes the transmitted and received signals to determine the distance between the user and objects in the given areas. A feedback system is operable with the processor for generating a feedback signal for each of the laser sensors as a function of the received laser signal.

Further, in carrying out the above objects and other objects, the present invention provides a method for a visually impaired user. The method includes transmitting laser signals in given areas corresponding to respective positions. The laser signals reflected from objects in the corresponding given areas are then received at the respective positions. The time between transmitted and received laser signals at the respective positions is indicative of the distance between the user and an object in the corresponding given area.



The transmission and reception of the laser signals at the respective positions may be enabled and disabled periodically to effect scanning of the given areas. A feedback signal is generated for each of the positions as a function of the received laser signal.

The advantages accruing to the present invention are numerous. The sensory system provides a visually impaired user with a footprint mental picture of the environment by scanning horizontally and vertically across a sensor array.

These and other features, aspects, and embodiments of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block view of an embodiment of the sensory system of the present invention;

FIG. **2** is a block view of another embodiment of the sensory system of the present invention;

FIG. **3** illustrates two sets of vibratory feedback devices;

FIG. **4** illustrates a glove for providing tactile feedback;

FIG. **5** illustrates an audio alarm; and

FIG. **6** is a block view of another embodiment of the present invention.

## BEST MODES FOR CARRYING OUT THE INVENTION

Referring now to FIG. **1**, an embodiment of a sensory system **10** is shown. Sensory system **10** includes a visor device **11** worn by a visually impaired user **12**. Visor device **11** may extend on the face of user **12** between the ears of the user to provide feedback on objects in front of the user. Visor device **11** may also be configured to be wrapped around the head and face of user **12** (not specifically shown) to provide feedback on objects around the user. In this configuration, visor device **11** enables user **12** to have 360° peripheral vision.

Visor device **11** includes an array of laser transmitters **14** and laser sensors **16**. As shown in FIG. **1**, visor device **11** is divided into a plurality of segments. Each segment has a transmitter **14** and a corresponding sensor **16**.

Transmitters **14** transmit laser signals along a highly directional beam at a given area in front of, or around, user **12**. Transmitters **14** are arranged and pointed such that each transmitter transmits toward a zone in the given area. Preferably, each transmitter **14** transmits a laser signal perpendicular to user **12**. Thus, the given area is divided into a plurality of zones with each zone corresponding to one of transmitters **14**.

Sensors **16** are operable to receive laser signals reflected from objects in the given area. Each sensor **16** corresponds to one of transmitters **14** and is operable to receive laser signals reflected from objects in one of the plurality zones. The time between a laser signal transmitted by one of transmitters **14** and received by a corresponding sensor **16** is indicative of the distance between user **12** and an object within the respective zone.

Sensory system **10** further includes a processor **18**. Processor **18** includes a power supply for supplying power to transmitters **14** for transmitting laser signals. Processor **18** processes the laser signals received by sensors **16** to determine the time between transmitted and received signals. Processor **18** then determines the distance between user **12** and an object within a respective zone of one of transmitters **14**.

Processor **18** scans the array of transmitters **14**. For instance, processor **18** controls the array such that one transmitter **14** transmits a signal while the other transmitters are idle. Processor **18** is further operable to determine if sensor **16** corresponding to transmitter **14** receives a reflected signal. This process is sequentially continued with the next transmitter **14** transmitting a signal and the corresponding sensor **16** set for receiving a reflected signal.

Preferably, array of transmitters **14** are swept along a horizontal sweep and then in a vertical sweep. To effect scanning of transmitters **14**, processor **18** enables and disables each of the transmitters by turning on and shutting off the supply power to the transmitters periodically.

Alternatively, processor **18** is operable to provide continuous supply power to transmitters **14** so that the transmitters are transmitting signals continuously. In this alternative embodiment, processor **18** is operable to process all of the reflected signals received by sensors **16**. Processor **18** then performs multiplexing, such as time division multiplexing (TDM), with the sensors **16** such that the sensors scan the given area for reflected signals. Alternatively, processor **18** is operable such that each element of the array continuously transmits and receives signals without scanning.

A feedback system **20** is operable with processor **18** to generate audible and/or tactile feedback signals for user **12**. The feedback signals are generated as a function of the received laser signal, i.e., the distance between user **12** and an object in a zone associated with a respective one of transmitters **14**. From the different feedback signals generated during the scanning of the array of transmitters **14** and/or sensors **16**, user **12** may form a mental picture of the objects within the surrounding environment. Because of the large numbers and highly directional capability of transmitters **14**, sensory system **10** allows user **12** to distinguish objects in the given area by using the different feedback signals.

Transmitters **14** and sensors **16** of the array may be scanned by electrical or mechanical means as known to those of ordinary skill in the art. Of course, a single source transmitter/sensor pair may be used in place of the array and scanned by electrical or mechanical means.

Referring now to FIG. **2**, an alternative embodiment of a sensory system **30** is shown. Sensory system **30** differs from sensory system **10** in that visor device **32** includes an array of ultrasonic transducers **34** instead of laser transmitters **14** and laser sensors **16**. Transducers **34** transmit ultrasonic signals and are arranged in an array such that each transducer transmits toward a zone in the given area. Thus, the given area in front of user **12** is divided into a plurality of zones with each zone corresponding to one of transducers **34**.

Transducers **34** are also operable to receive ultrasonic signals reflected from objects in the given area. Transducers **34** have the same reception and transmission patterns so that a transducer receives ultrasonic signals reflected from an object in a respective zone in the given area. The time between an ultrasonic signal transmitted by one of transducers **34** and received by that transducer is indicative of the distance between user **12** and an object within the respective zone.

Processor **18** determines the time between transmitted and received ultrasonic signals. Processor **18** then determines the distance between user **12** and an object within a respective zone of one of transducers **34**. Feedback system **20** is operable with processor **18** to generate a feedback signal for each of transducers **34** as a function of the received ultrasonic signal.

The feedback signals provided by feedback system **20** may take on a variety of forms. For instance, as shown in FIG. **3**, feedback system **20** may be operable with two sets **42**(a-b) of a plurality of vibrators **44**. Vibrators **44** provide tactile stimulation to user **12**. Sets **42**(*a–b*) may be formed on an adhesive suitable for placing on the hands or sides of the face of user **16**. Sets **42**(*a–b*) may also be implanted into the body of user **12**. Each vibrator **44** is associated with a respective sensor **16** (or transducer **34**). Thus, each vibrator **44** corresponds to a respective zone within the given area. Other feedback forms include force-surface pressure signals.

When a sensor **16** receives a reflected signal transmitted by a corresponding transmitter **14**, feedback system **20** stimulates that vibrator **44** associated with that sensor to notify user **12** of the distance between him and an object within a zone in a given area. Feedback system **20** stimulates the various vibrators **44** as the array of transmitters **14** and sensors **16** are scanned so that user **12** can form a mental picture of the surrounding environment.

Feedback system **20** varies the stimulation of a vibrator **44** as a function of the distance between user **12** and an object. For instance, the frequency or magnitude of vibration may be varied as a function of the distance between user **12** and an object. A higher frequency or magnitude may imply that the object is close to user **12**. On the other hand, a lower frequency or magnitude may imply that the object is far from user **12**. Vibrators **44** may also be configured to apply heat and/or force-surface pressure as a function of the distance between user **12** and an object.

Referring now to FIG. **4**, feedback system **30** is operable with a pair of gloves **46** (only one shown) for the hands of user **12**. Glove **46** is provided with muscle wires **48**. Muscle wires **48** include shaped memory alloys (SMA), solenoid switches, or the like. Muscle wires **48** tighten in response to a supplied voltage. Accordingly, each muscle wire is either on or off and provides two bits of data. Glove **46** is shown in FIG. **4** as having three muscle wires **48** for each finger and thumb portion of the glove. Thus, each finger and thumb portions have eight bits of data. Each finger and thumb portion of glove **46** preferably corresponds to one of transmitters **14** and sensors **16**. In this case, the array of transmitters **14** and sensors **16** consists of ten transmitter/sensor pairs with each finger and thumb portion corresponding to one of the pairs.

The eight bits of data provided by the three muscle wires **48** is indicative of detected objects in the zone covered by the corresponding pair. For example, each bit may represent three feet that an object in a zone is near user **12**. Muscle wires **48** may be configured to provide different amounts of tightening. For instance, muscle wires **48** may provide strong and weak tightening in addition to no tightening. In this case, each muscle wire **48** provides three (instead of two) bits of information. As a result, twenty seven bits of data are provided by three muscle wires and each bit may represent one foot that an object in a zone is near user **12**.

Referring now to FIG. **5**, feedback system **20** may also include an audio amplifier **56**. Audio amplifier **56** is con-

nected to a pair of ear speakers **58**(*a–b*) by speaker cable **60**. Audio amplifier **56** is associated with each of sensors **16** (or transducers 34) for providing audio feedback signals to user **12**. Other devices instead of pair of ear speakers **58**(*a–b*) for providing the audio feedback signals to user **12** include a single ear plug, a "bone phone", etc.

Audio amplifier **56** provides an audio feedback signal for a respective one of sensors **16**. The audio feedback signals may have different tones (frequencies) for each sensor **16**. For example, there may be twenty different tones for twenty sensors.

Each audio feedback signal corresponds to a respective zone within the given area. When a transmitter **14** transmits and the corresponding sensor **16** receives a laser signal, audio amplifier **56** generates a particular audio feedback signal associated with that sensor to notify user **12** of the distance between him and an object within a zone in a given area. Feedback system **20** generates the various audio feedback signals as transmitters **14** and sensors **16** are scanned so that user **12** can form a mental picture of the surrounding environment.

Audio amplifier **56** varies the volume of the audio feedback signals as a function of the distance between user **12** and an object. A higher volume may imply that the object is close to user **12**. On the other hand, a lower volume may imply that the object is far from user **12**.

Audio amplifier **56** may also provide audio feedback signals to user **12** as a function of the interaural volume. In this embodiment, audio amplifier **56** generates audio feedback signals having ten different tones for two sets of ten sensors. Each tone is associated with a respective sensor in the two sets. Audio amplifier **56** varies the volume of the audio feedback signal provided to each ear as a function of the distance between user **12** and objects within the two zones corresponding to the two transducers.

The feedback signals may be provided to user **12** in different patterns during scanning of the array of transmitters **14** and sensors **16**. Feedback system **20** may generate the audio feedback signal for a respective sensor **16** during the time that the corresponding transmitter **14** is transmitting a laser signal. The audio feedback signal is turned off once the associated transmitter **14** and/or sensor **16** is disabled. In this embodiment, the audio feedback signals follow the scanning of the array of transmitters **14** and sensors **16**. For instance, stimulation of vibrators **44** moves horizontally and vertically across the hands of user **12** during scanning. Similarly, the tones of the audio alarm signals change during scanning.

Alternatively, feedback system **20** may generate an audio feedback signal for a sensor **16** and then hold that signal for a period of time until the sensor receives a different reflected signal. Once a different reflected signal is received, feedback system **20** generates a new audio feedback signal.

In another alternative embodiment, feedback system **20** may generate an audio feedback signal for a respective sensor **16** and then hold that signal until a scanning cycle of the array of transmitters **14** and sensors **16** has been completed.

Referring now to FIG. **6**, an alternative embodiment of a sensory system **60** is shown. Sensory system **60** includes a visor device **62** worn by user **12**. Visor device has ultrasonic transducers **64**. Sensory system **60** uses echo location similar to that used by whales, dolphins, and bats. To this end, transducers **64** transmit ultrasonic signals for a given period of time. Transducers **64** then listen to receive ultrasonic signals which are reflected from objects around user **12**.

A processor **66** is operable with transducers **64** to perform signal processing. Processor **66** sums all of the received signals from transducers **64** to form a sum signal. The sum signal corresponds to the objects surrounding user **12**. Thus, the sum signal changes as the objects surrounding user **12** change orientation and position.

A feedback system **68** operable with processor **66** then shifts the frequency of the sum signal down to an audible frequency for user **12**. User **12** then listens to the down-shifted frequency sum signal. By being able to differentiate the sum signals through training and experience, user **12** may be able to form a mental picture of the surrounding environment.

It should be noted that the present invention may be used in a wide variety of different constructions encompassing many alternatives, modifications, and variations which are apparent to those with ordinary skill in the art. Accordingly, the present invention is intended to embrace all such alternatives, modifications, and variations as fall within the spirit and broad scope of the appended claims.

The embodiments of the sensory systems of the present invention share the feature of providing enough data to a user such that, through training and experience, the user can use the data to form a mental picture of the environment. In essence, instead of processing light for vision like sight unimpaired individuals, the sight impaired user processes the feedback data for vision.

To this end, other sensory system embodiments, such as machine vision, may be utilized. For instance, information on the surrounding environment is processed by a machine vision computer. The computer can then process the information to form a signal indicative of the surrounding environment. Through experience, a sight-impaired user can distinguish among signals to form a mental picture of the surrounding environment.

What is claimed is:

1. A sensory system for a visually impaired user comprising:

an array of laser transmitters for transmitting laser signals in a total coverage area consisting of a plurality of given areas, each of the laser transmitters transmitting a laser signal in a corresponding given area;

an array of laser sensors for receiving laser signals reflected from objects in the total coverage area, each of the laser sensors corresponding to a respective one of the array of laser transmitters for receiving a reflected laser signal from an object in the corresponding given area, wherein the time between transmitted and received laser signals of a laser transmitter and the respective laser sensor is indicative of the distance between the user and an object in the corresponding given area;

a processor operable with the array of laser transmitters and laser sensors to process the transmitted and received laser signals to determine the distance between the user and objects in each of the given areas; and

a feedback system operable with the processor for generating a feedback signal for each of the laser sensors, the feedback system generating each feedback signal as a function of the distance between an object in the corresponding given area and the user, wherein the user uses all of the feedback signals corresponding to each of the given areas to establish a mental picture of the objects in the total coverage area.

2. The system of claim **1** wherein:

the processor is operable to periodically enable and disable the array of laser transmitters and laser sensors to effect scanning of the given areas of the total coverage area.

3. The system of claim 2 wherein:

the feedback system generates the feedback signal for each of the laser sensors during the time that the respective laser transmitter is enabled.

4. The system of claim 2 wherein:

the feedback system generates the feedback signal for each of the laser sensors until the respective laser transmitter is subsequently enabled.

5. The system of claim 2 wherein:

the feedback system generates the feedback signal for each of the laser transmitters until a scanning cycle of the array of laser transmitters has been completed.

6. The system of claim 1 wherein the alarm system comprises:

a plurality of vibrators with at least one vibrator being associated with each of the laser sensors for generating a vibratory feedback signal for the respective laser sensor.

7. The system of claim 6 wherein:

the plurality of vibrators have a given frequency of vibration, wherein the given frequency of vibration is a function of the distance between the user and the object in the corresponding given area.

8. The system of claim 1 wherein the feedback system comprises:

an audio amplifier associated with each of the laser sensors for generating an audio feedback signal for the respective laser sensor.

9. The system of claim 8 wherein:

the audio feedback signal has a given audio frequency, wherein a given audio frequency is a function of the distance between the user and the object in the corresponding given area.

10. The system of claim 8 wherein:

the audio feedback signal has a given volume, wherein a given volume is a function of the distance between the user and the object in the corresponding given area.

11. A method for a visually impaired user comprising:

transmitting a laser signal in each of a corresponding given area of a total coverage area;

receiving laser signals reflected from objects in the total coverage area, each of the reflected laser signals being reflected from an object in the corresponding given area with each received laser signal corresponding to a respective transmitted laser signal, wherein the time between transmitted and received laser signals is indicative of the distance between the user and an object in the corresponding given area;

processing the transmitted and received laser signals to determine the distance between the user and objects in each of the given areas; and

generating a feedback signal for each of the received laser signals, each feedback signal generated as a function of the distance between the object in the corresponding given area and the user, wherein the user uses all of the feedback signals corresponding to each of the given areas to establish a mental picture of the objects in the total coverage area.

12. The method of claim 11 further comprising:

enabling and disabling the transmission and reception of the laser signals periodically to effect scanning of the given areas.

13. The method of claim 11 wherein:

the feedback signal is a plurality of vibrations with at least one vibrator being associated with each of the received signals for generating the feedback signal for the corresponding given areas.

14. The method of claim 13 wherein:

the plurality of vibrators have a given frequency of vibration, wherein the given frequency of vibration is a function of the distance between the user and the object in the corresponding given area.

15. The method of claim 11 wherein:

the feedback signal is an audio signal.

16. The method of claim 11 wherein:

the audio signal has given audio frequencies, wherein a given audio frequency is a function of the distance between the user and the object in the corresponding given area.

17. The method of claim 16 wherein:

the audio signal has a given volume, wherein a given volume is a function of the distance between the user and the object in the corresponding given area.

18. A sensory system for a visually impaired user comprising:

an array of ultrasonic transducers for transmitting ultrasonic signals in the environment surrounding the user, each of the ultrasonic transducers further operable to receive ultrasonic signals reflected from objects in the surrounding environment;

a processor operable with the array of ultrasonic transducers to process the reflected ultrasonic signals received by the transducers, wherein the processor processes the received signals to form a sum signal; and

a feedback system operable with the processor for generating an audio feedback signal as a function of the sum signal by down shifting the frequency of the sum signal to an audible frequency, wherein the user listens to the audio feedback signal to determine objects in the surrounding environment.

19. A sensing system for a visually impaired user comprising:

an array of ultrasonic transducers for transmitting and receiving ultrasonic signals in a total coverage area consisting of a plurality of given areas corresponding to each of the ultrasonic transducers, wherein the time between transmitted and received ultrasonic signals of an ultrasonic transducer is indicative of the distance between the user and an object in the corresponding given area;

a processor operable with the array of ultrasonic transducers to process the transmitted and received ultrasonic signals to determine the distance between the user and objects in each of the given area; and

a feedback system operable with the processor for generating a feedback signal for each of the ultrasonic transducers, the feedback system generating each feedback signal as a function of the distance between an object in the corresponding given area and the user, wherein the user uses all of the feedback signals corresponding to each of the given areas to establish a mental picture of the objects in the total coverage area.

20. The system of claim 19 wherein:

the processor is operable to periodically enable and disable the array of ultrasonic transducers to effect scanning of the given areas by the array.

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